FIRE BEHAVIOR AND NUMERICAL SIMULATION OF FACADE ELEMENTS FOR BUILDINGS

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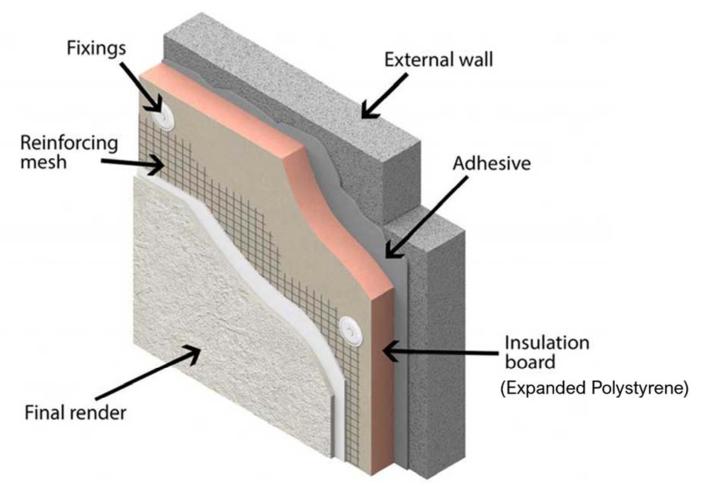
Introduction

In Europe, the external thermal insulation (ETI) has been developed extensively. However, this potentially translates into an increase in the fuel mass and fire propagation on the facade because the insulation materials are generally derived from plastic (PE, EPS, PIR, etc.).

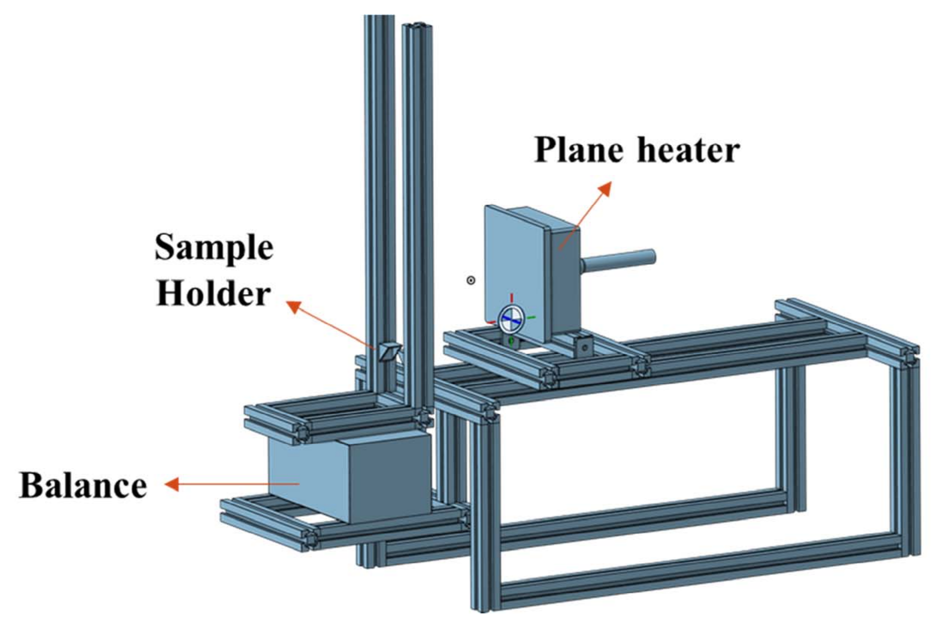


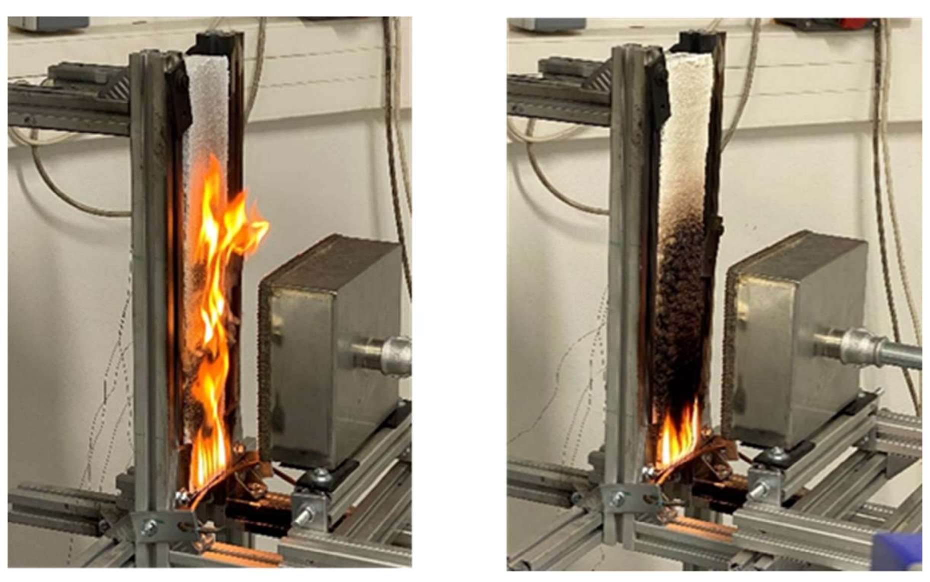
Insulation board	EPS
Fixing render	68%Si, 14%Al, 9%Ca, 6%Mg
Final render	53%Ca, 24%Si, 11%Al, 7%Ti

Objective

- Describe the thermal decomposition process of ETI elements at small scale
- Characterize the flame-facade interaction and propagation at intermediate-scale
- Study some intumescent coating configurations for the fire protection of the facade at larger scale

Test Bench





A prototype by combining a plane radiant heater with a horizontal and rotational motion

Results

TGA

EPS	
E_a	177,619 kJ/mol
$Log(PreExp)$	11,996 Log(1/s)
n	1,184
θ	1,004

Finition	Step1	Step2
E_a	79,901 kJ/mol	356,130 kJ/mol
$Log(PreExp)$	4,988 Log(1/s)	16,782 Log(1/s)
n	2,491	2,252
θ	0,463	0,536

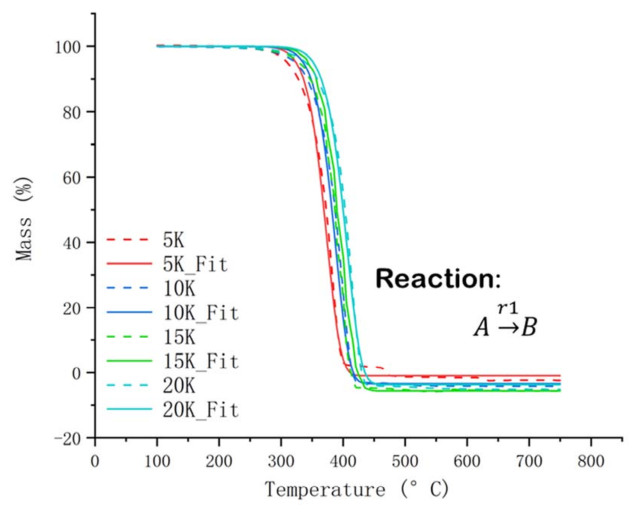


Fig.1 TG fit curves of EPS in air

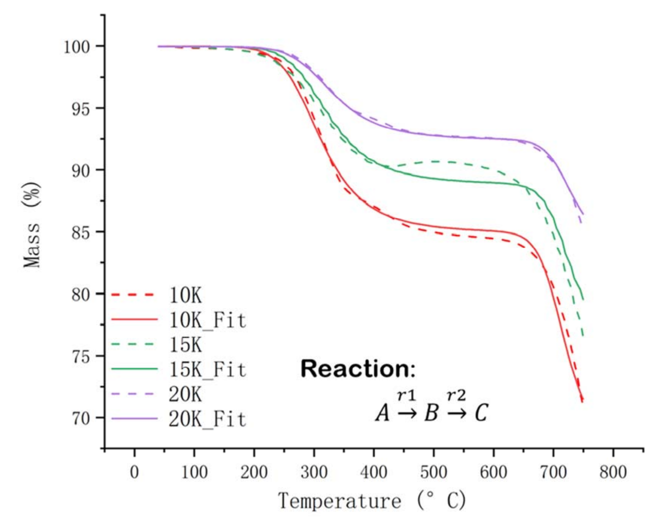


Fig.2 TG fit curves of final render in air

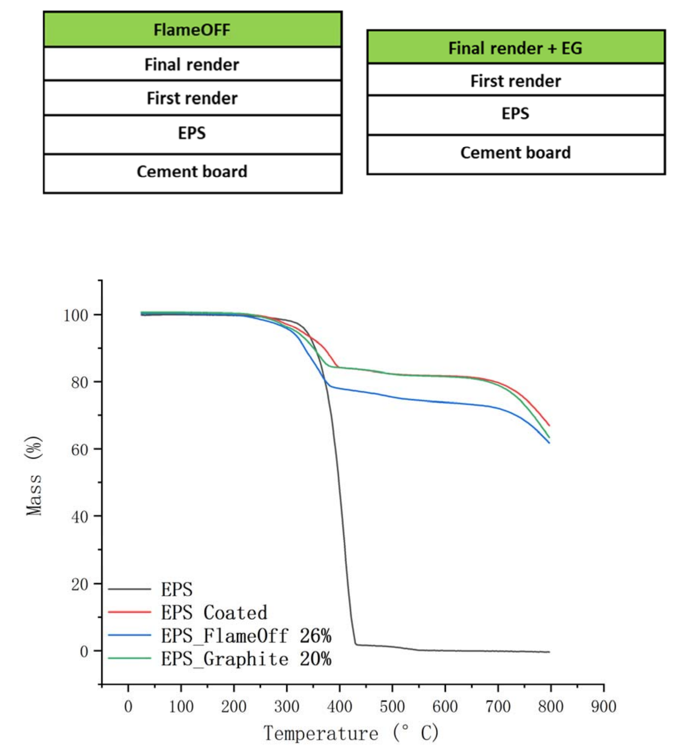


Fig.3 TG curves of different ETI in 10K/min in air

STA

Step	Enthalpy (J/g)	Onset Temperature(°C)	Mass Loss(%)
M	160.8	T_i = 44	-
		T_f = 125	
1	-603.1	387.3	98.22

Step	Enthalpy (J/g)	Onset Temperature(°C)	Mass Loss(%)
1	-418,113	318,9	99,98

Step	Enthalpy (J/g)	Onset Tenperature(°C)	Mass Loss(%)
1	-98.48	184	6.17
2	-82.16	395.7	15.56
3	-438.8	750.1	16.37

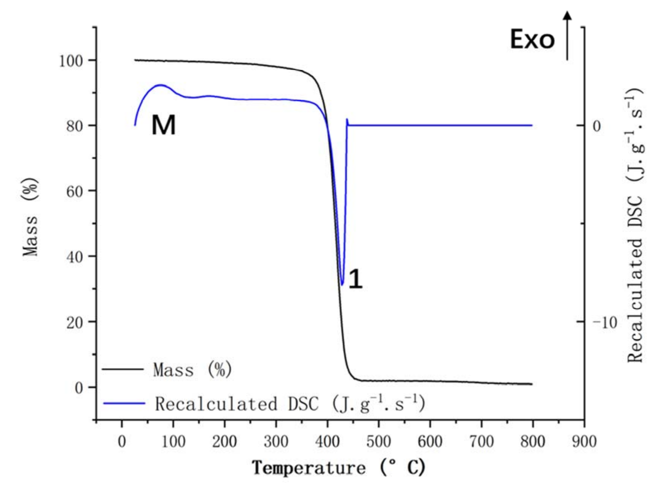


Fig.4 STA curves of EPS in 10K/min in nitrogen

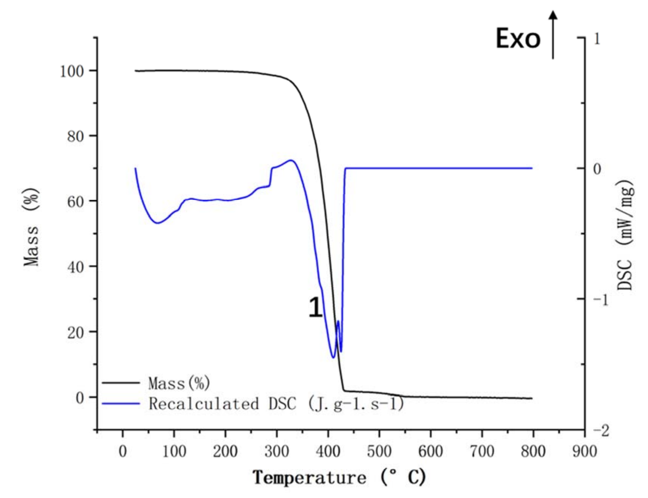


Fig.5 STA curves of EPS in 10K/min in air

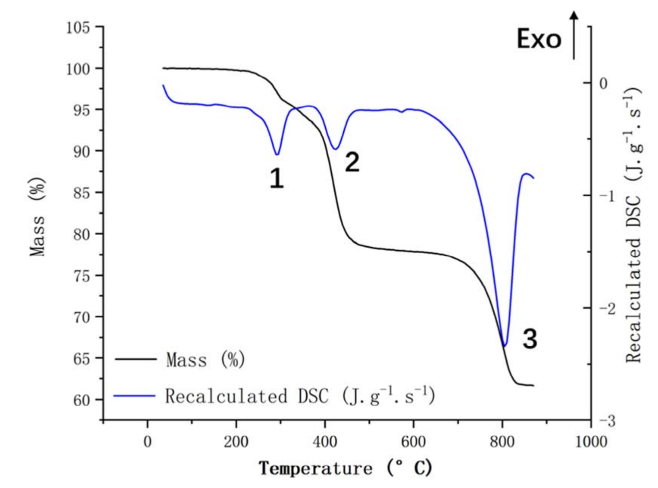


Fig.6 STA curves of ETI in 10K/min in nitrogen

Temperature Profile

Condition: Plane heater 10cm, 0° no incline, 60 kW/m²

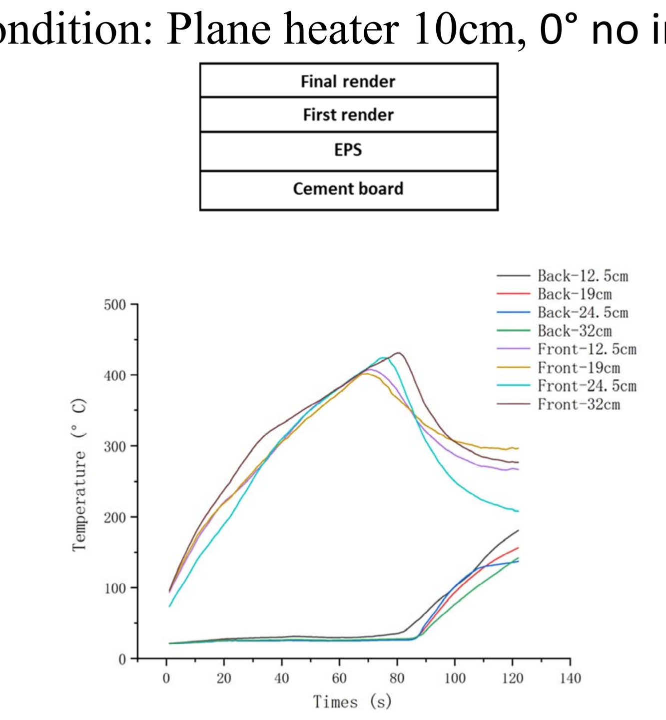


Fig.7 Temperature curves of commercial ETI

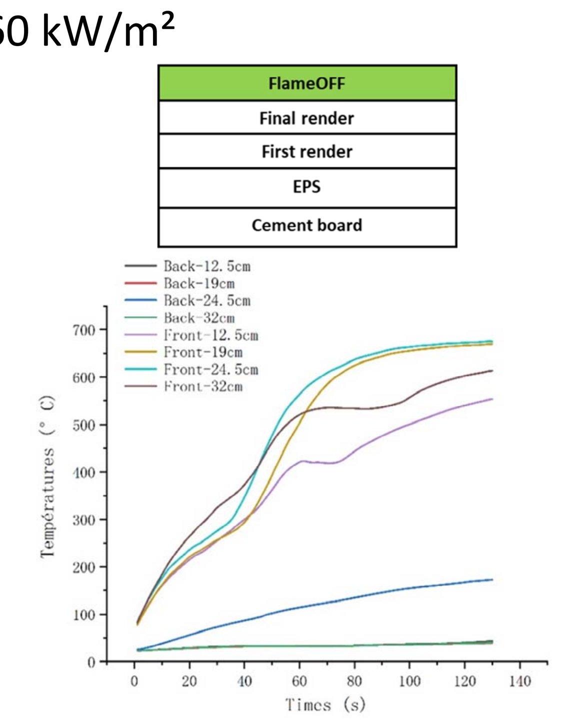


Fig.8 Temperature curves of ETI + FlameOFF

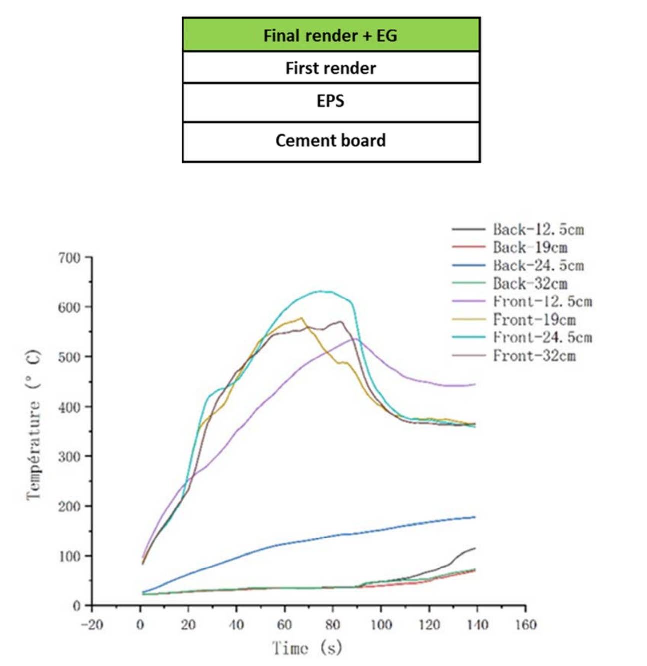


Fig.9 Temperature curves of ETI + EG

Simulation– EPS degradation

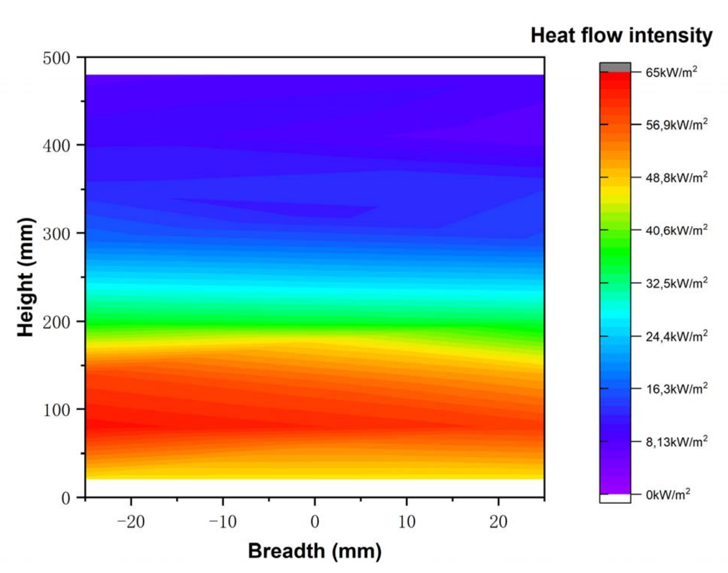


Fig.10 Distribution of heat flux on facade

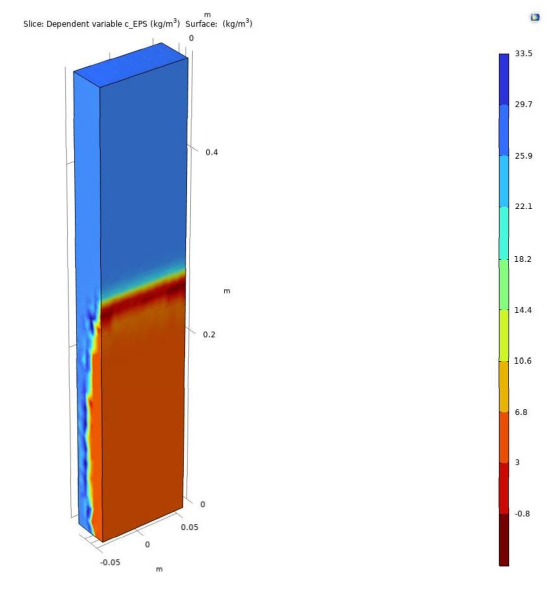


Fig.11 Simulated EPS Concentration at 200s

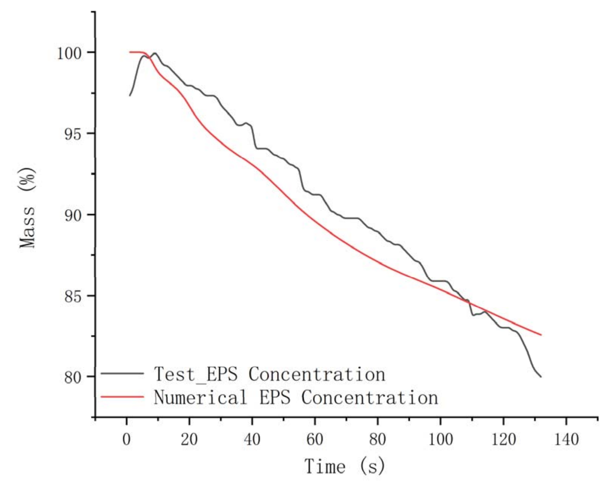


Fig.12 Comparison of mass loss

Conclusion

An original test bench at intermediate scale is introduced, equipped with a plane radiant heater movable horizontally and rotationally, to study the thermal decomposition and the flame propagation. The new insulation coating by adding FlameOFF or Expandable Graphite works well in heat protection.

With kinetic parameters of reaction investigated by TGA, like reaction order, activation energy and pre-exponential factor, it is possible to define the rate of decomposition of ETI materials as a function by using Arrhenius law. Then, the heat of gasification and decomposition could be evaluated from STA. Based on these parameters, a pyrolysis model was built, which contribute to understanding the observed phenomena.